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13. ABSTRACT (Maximum 200 words)
A description of the scope of work and important results from AASERT funding is presented. The major areas of sutdy included the types of defects produced by mechanical deformation, fracture, polishing, and abrasion on inorganic single crystals and polymer surfaces and the way these defects interacted with UV laser irradiation. The use of photoluminescence to quantitatively and spatially characterize these defects is described. The role of such defects in the way intense laser light couples to normally transparent materials was also investigated.

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Final Report
AASERT: Fracto-Emission from Metal Ceramic Interfaces
Parent Award: F496720-91-C-0093 P00001
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by

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The student supported by this grant was Richard Webb. During this period Richard devoted most of his time to laboratory experiments. He also took a course in the Characterization of Materials, participated in seminars on the Design and Evaluation of Materials Related Experiments, and attended several lectures by quest speakers on Topics in Materials Physics. His grades have been maintained well above a B average. Richard also presented papers on his work at a March Meeting of the American Physical Society and a Fall Meeting of the American Vacuum Society. He also presented his work at a seminar at Pacific Northwest Laboratory in Richland, Washington.

His laboratory projects initially focused on mechanical processes which induce plastic deformation in single crystal MgO and NaCl and the accompanying point defects created by this deformation. The spectroscopy of point defects in these materials is well known and the defects themselves readily detected. Richard showed that high concentrations of dislocation derived F-centers (oxygen atom vacancies) lead to strong coupling with the laser which actually result in melting of the crystal, its vaporization into the gas phase, and drastic modification of the surface.

In addition, Richard showed that reduced laser intensities can produce highly localized modification of MgO cleavage surfaces. Here, cleavage produces high concentrations of defects along cleavage steps. Localized heating can be shown to result in metallic Mg coming to the surface. The appearance and distribution of the modified areas is consistent suggests that heating was localized to dislocation cores. We suggest that these studies are a way to characterize the plasticity that occurs in fracture and in tribological loading of ceramics surfaces.

Richard also developed an exciting new way to image the regions of high point defect concentrations using photoluminescence. The spectra of these centers has been acquired and shown to be due to clusters of F-centers concentrated along dislocations. Indents, scratches, cleavage steps, and other features have been imaged successfully.

In the last year of his thesis research (after the termination of this grant), Richard applied and extended his work with mechanical defects and laser interactions. Mechanical defects were found to be especially important in the localized ablation from the "back side" of MgO crystals, where the laser beam passes through the crystal and ablates material from side of the crystal facing away from the incident irradiation. He also studied the effect of abrasion on the ion/molecule emission detected from solution-cast PMMA films under 308-nm irradiation, and the effect of laser-generated shocks on the particle size distribution of the "smoke" produced by

irradiating single crystal $NaNO_3$ at 248-nm in air. For completeness, the expected publications resulting from this work are included below.

Richard defended his Ph. D. thesis in August, 1995, and accepted a tenure-track position in the Department of Physics and Computer Science at Pacific Union College in Angwin, California where his principle duties are to teach undergraduate physics.

All funds were expended as salary for Richard and to purchase supplies used in his research.

The results of the above studies are or will be published in the following articles:

R. L. Webb, S. C. Langford, L. C. Jensen, and J. T. Dickinson, "Ablation of single crystal MgO by UV excimer laser radiation", Mat. Res. Soc. Symp. Proc. 236, 21 (1992).

R. L. Webb, L. C. Jensen, S. C. Langford, and J. T. Dickinson, "Interactions of wide bandgap single crystals with 248 nm excimer laser radiation: I. MgO", J. Appl. Phys. 74, 2323-2337 (1993).

R. L. Webb, L. C. Jensen, S. C. Langford, and J. T. Dickinson, "Interactions of wide bandgap single crystals with 248 nm excimer laser radiation: II. NaCl", J. Appl. Phys. 74 2338-2346 (1993).

J. T. Dickinson, L. C. Jensen, R. L. Webb, M. L. Dawes, and S. C. Langford , "Interactions of wide bandgap single crystals with 248 nm excimer laser radiation: III. the role of cleavage-induced defects in MgO," J. Appl. Phys. 74 3758 (1993).

J. T. Dickinson, L. C. Jensen, R. L. Webb, and S. C. Langford, "Laser ablation of wide band-gap materials: The role of defects in single crystal MgO," Proceedings of the Second International Conference on Laser Ablation (COLA-II), AIP Conf. Proc. 288, J. C. Miller and D. B. Geohegan, eds., pp. 13-25 (1993).

J. T. Dickinson, L. C. Jensen, R. L. Webb, and S. C. Langford, "Laser ablation studies relevant to thin film deposition," in *Advanced Materials '93. IV. Laser and Ion Beam Modification of Materials*, edited by I. Yamada et al. [Trans. Mater. Res. Soc. Jpn. 17], 283-288 (1994).

J. T. Dickinson, L. C. Jensen, R. L. Webb, M. L. Dawes, and S. C. Langford, "Mechanisms of excimer laser ablation of wide bandgap materials: the role of defects in single crystal MgO," MRS Symposium Proceedings 285, 131 (1993).

J. T. Dickinson, L. C. Jensen, and R. L. Webb, "Photoluminescence imaging of mechanically produced defects in MgO," J. Non-Cryst. Solids 177, 1-8 (1994).

R. L. Webb, S. C. Langford, and J. T. Dickinson, "Neutral atom and molecule emission accompanying 248-nm laser irradiation of single crystal $NaNO_3$," Nucl. Instrum. Meth. Phys. Res. B. 103, 297-308 (1995).

R. L. Webb, G. Exarhos, and J. T. Dickinson, "Characterization of particulates generated from laser ablation of single crystals of $NaNO_3$," in preparation.

R. L. Webb, L. C. Jensen, and J. T. Dickinson, and C. R. Davis, "Sensitization of PMMA to excimer laser ablation at 308 nm wavelength," in preparation.

R. L. Webb and J. T. Dickinson, "The role of defects in the rear side laser ablation of MgO at 308 nm," in preparation.

R. L. Webb and J. T. Dickinson, "Positive ion emission from 248-nm irradiated sodium nitrate," in preparation.

Richard also assisted in two experiments involving a new technique for examining the plasticity of metals during the deformation and fracture of metals and the fracture of a metal-glass interface. These studies were published in:

J. T. Dickinson, L. C. Jensen, S. C. Langford, and R. G. Hoagland, "Chemisorptive electron emission as a probe of plastic deformation in reactive metals," J. Mater. Res. 9, 1156-1165 (1994).

Sumio Nakahara, S. C. Langford, and J. T. Dickinson, "Chemisorptive electron emission and atomic force microscopy as probes of plastic deformation during fracture at a metal/glass interface ," J. Mater. Res. 10(8), 2033-2041 (1995).